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APPLICATION FOR UNITED STATES LETTERS PATENT

for

**METHOD AND APPARATUS FOR FUEL  
ADDITIVE DISPENSING**

by

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1 **RELATED APPLICATION**

2 Pursuant to 37 C.F.R. § 1.78, this application claims the priority of provisional  
3 application Serial Number 60/123,627 filed on March 10, 1999, the content of which being  
4 hereby incorporated by reference herein in its entirety.

5 **FIELD OF THE INVENTION**

6 The present invention relates generally to the dispensing of fuel additives, and more  
7 particularly to a system for adding fuel additives into a fuel refueling stream at a fuel dispenser.

8 **BACKGROUND OF THE INVENTION**

9 The present invention relates to the addition of fuel additives into the fuel refueling  
10 stream at a fuel dispenser, simultaneous with a customer refueling his/her automobile in an  
11 otherwise normal manner.

12 Fuel additives are well known in the art. Such additives are typically petroleum-based or  
13 synthetic chemical products that can be formulated to address specific driving or automotive  
14 performance issues when added to gasoline or diesel fuels. Examples of the benefits of such  
15 additives include helping to clean fuel system components, enhancing overall engine  
16 performance, improving fuel economy, reducing emissions and preventing freezing of fuel lines  
17 in cold weather conditions.

18 Fuel additives are commonly blended into fuels at bulk loading terminals, for eventual  
19 retail sale through fuel dispensers as so-called "blended products." Treat rates (i.e., the  
20 concentration levels) for such additives are low, as additization levels are primarily intended to  
21 enable the fuel to meet minimum EPA regulatory requirements. In response to the known  
22 benefits of fuel additives added to fuels in more concentrated levels, a market has developed  
23 over time for bottled after-market additives. Such additives can enable treat rates many times  
24 that of pre-blended additives, and, as a result, greatly enhance cleaning, performance and other  
25 benefits to consumers.

26 The purchase and use of bottled after-market additives can be an inconvenient, messy,  
27 and cumbersome process. Bottled additives must be purchased from a retail store and  
28 manually poured into the vehicle fuel tank prior to refueling. This process is often smelly and  
29 messy, as liquid can spill on the car or a consumer's clothing as the additives are being poured  
30 into the vehicle fuel tank. Customers must also decide the quantity of the bottle of additive  
31 required, based on the amount of fuel to be dispensed and recommended additive treat rates.

1 Until they are properly discarded, partially-used additive containers are often left to roll around  
2 in the back seat or trunk of a vehicle, and can leak if bottles or cans are not properly secured.  
3 These aspects of the purchase and use of such additives are believed to have limited the  
4 market for such products.

5 Various methods to facilitate the blending of fuel additives into fuels at fuel dispensers  
6 have been addressed in prior art. For example, U.S. Patent No. 4,131,215 to Hansel and U.S.  
7 Patent No. 5,163,586 to Zinsmeyer propose fuel dispensers with additive dispensing  
8 capabilities in which a fuel additive may be dispensed along with fuel, and the cost of the fuel  
9 plus additive combined to result in one blended price to the consumer. These technologies  
10 appear to be applicable only to newly manufactured fuel dispensers. In addition, such  
11 technologies would seem to require extensive redevelopment and upgrading of existing station  
12 fuel dispensers and point-of-sale systems to support the functionality required for fuel additive  
13 injection at fuel dispensers. As such, the aforementioned patents do not seem to address the  
14 need for technology for upgrading (i.e., retrofitting) existing fuel dispensers in the field.

15 U.S. Patent No. 5,018,645 to Zinsmeyer proposes a fuel additive dispensing system  
16 separate from the fuel dispenser, in which additives are be blended into dispensed fuel, with the  
17 cost and amount of additive being displayed separately from that of the fuel. This technology  
18 involves a method for separating the fuel additive dispensing unit from the fuel dispenser.  
19 However, there remains a need in the art for technology that can be physically attached to any  
20 make or model of fuel dispenser, which can support full integration with existing station point-of-  
21 sale systems without the need for redevelopment or extensive upgrading of such point-of-sale  
22 systems, and which can support the multiple modes of customer selection, operation, and  
23 payment that is desirable for operating fuel additive dispensing systems.

24 Various technologies have also been shown in prior art for metering and blending of  
25 additives into fuels. For example, U.S. Patent No. 4,253,436 to Dudrey proposes a system that  
26 includes a control unit for delivering a predetermined quantity ratio of additive to the amount of  
27 fuel pumped into a particular tank. U.S. Patent No. 4,621,593 to Rao et al. proposes an  
28 apparatus for dispensing an additive into a fuel tank in dependence upon the level of fuel within  
29 a fuel tank. U.S. Patent No. 5,251,785 to Hayden proposes a method of using electromagnetic  
30 energy transmitted through a window to blend additive into a flow stream at a controlled rate.  
31 U.S. Patent No. 5,331,994 to Bryan proposes a system in which a minimum of three fuel level  
32 readings taken at fixed periods can be used to control the operation of an additive dispensing  
33 pump and maintain additive at a predetermined additive concentration with respect to the fuel.

1 U.S. Pat No. 5,441,072 to Indey, et al. proposes a method of dispensing additive at a variable  
2 rate corresponding to monitored variations in fuel flow rate. Finally, various technologies have  
3 been proposed for controlling the addition of an additive to the fuel while an engine is running  
4 through use of on-board additive tanks; U.S. Patent No. 4,727,827 to Hoffman et al. and U.S.  
5 Patent No. 5,195,466 to Schulte et al. are two examples of this.

6 In general, while each of these prior technologies addresses methods and processes  
7 that may support the injection of fuel additives at fuel dispensers, testing and evaluation of  
8 various metering methods indicates that there remains a need in the art for the development of  
9 metering technology suitable for the injection of fuel additives at fuel dispensers.

## SUMMARY OF THE INVENTION

In view of the foregoing and other considerations, the present invention relates to a fuel additive dispensing system for a vehicle refueling station that enables customers at fuel dispensers to conveniently purchase and automatically blend supplemental fuel additives with their fuel during an otherwise normal refueling process. Further, the present invention enables a customer to pay for the additives in the same form and manner as that of their fuel and/or other purchase items.

The disclosed invention includes several key components, including one or more additive storage tanks and flow lines, one or more fuel additive dispensing units that attach to existing (or new) fuel dispensers and provide fuel additive service to one or both sides of said fuel dispensers, electronic control and microprocessor components incorporated into each fuel additive dispensing unit that monitor customer actions and adjacent fuel dispenser conditions including grade of fuel selected and fuel flow volumes, hydraulic metering and injection equipment incorporated into each fuel additive dispensing unit that enable the injection of precise volume increments of fuel additives corresponding to successive, selectable volume increments of fuel, audiovisual display screens incorporated into each fuel additive dispensing unit that provide product and transactional information to customers through state-specific audiovisual sequences, and network computer control equipment that provides centralized control for fuel additive dispensing unit operational and transactional processes and enables fuel additive transactions to be integrated with corresponding fuel transactions for customer payment in the same form and manner as that of the fuel and/or other purchases.

For a field system installation, fuel additive dispensing units are attached to one or more fuel dispensers at a fueling station site. One dispensing unit can provide service to one or both sides (i.e. both fueling position locations) of a single fuel dispenser, and enable the choice of one or more types of additive products to customers. In accordance with one embodiment of the invention, a dispensing unit may be physically connected to the fuel dispenser through multiple physical, hydraulic, and electronic interconnections, through the use of various housings, flanges, and electronic cables that may vary based on the fuel dispenser make and model. Each dispensing unit at a site is also connected to two additional systems: one or more additive storage and pressuring systems that provide supplies of fuel additives to each dispensing unit, and a central network server that directs operational and transactional activities of all dispensing units located at a site. In accordance with another aspect of the invention, access to storage and pressuring means may variously be either internal or external to each

1 dispensing unit, and the central network server may be either a stand-alone system or  
2 integrated within the body of the existing station point-of-sale system. The system design and  
3 manner of physical integration at a site enables existing fueling stations to be upgraded to  
4 include fuel additive dispensing capabilities without the need for extensive redevelopment,  
5 remanufacture, and reinstallation of the existing fuel dispensers or point-of-sale systems.

6 The primary interface between the invention and customers at fuel dispensers is through  
7 a graphic display integrated into the fuel additive dispensing unit. Such display is preferably  
8 located within the customer's normal field of vision with respect to the fuel dispenser, and can  
9 be canted toward the customer at an angle, to facilitate visibility and use. The display and  
10 accompanying electronic and computer control systems enable the dispensing unit to monitor  
11 operating and transactional information on the invention and the adjacent fuel dispensing  
12 equipment on a real-time basis, including grade of fuel selected and fuel flow volume. Further,  
13 the display and electronic systems are preferably capable of simultaneously displaying multiple  
14 types of text, graphics, and transactional information in different areas of the display screen.

15 A display system associated with the dispensing in accordance with the present  
16 invention can preferably display running totals for the purchase of fuel additives by itself or  
17 simultaneous with the display of other information, and provide interactive, state-specific,  
18 graphical and/or textual display information to customers, such that each of any number of  
19 additive dispensing systems at a site can display separate display content for each customer,  
20 thereby responding to specific modes of customer activity or equipment conditions at either the  
21 additive dispenser or the adjacent fuel dispenser. Preferably, the display and associated  
22 electronic system can send and receive transactional information required to support customer  
23 payment in the same form and manner as for the fuel or other purchases. In one embodiment,  
24 the video display may include an audio speaker to support the presentation to customers, and a  
25 proximity detector that can sense the presence of a customer or automobile so that video  
26 and/or audio content can be initiated or changed as a customer approaches the fuel dispenser.

27 Each fuel additive dispensing unit located at a site can interconnect either at the fuel  
28 dispenser with electronic circuitry that enables additive transactions to be integrated with the  
29 fuel transactions through the existing retail point-of-sale system, or via network computer  
30 communication (traditional cable or RF, for example) to a separate, stand-alone computer  
31 network server which functions as a central network control hub separate from the station retail  
32 point-of-sale system. Interactions between a central network server and each dispensing unit  
33 support the various transaction authorization, control, processing, data storage, and video

1 display functions that are necessary for invention operation. In addition, the central network  
2 server also interfaces with the existing retail station point-of-sale system to enable fuel additive  
3 transactions to be matched with the corresponding fuel transactions and facilitate payment of  
4 the additives in the same form and manner as for the fuel or other purchases.

5 In accordance with one aspect of the invention, consumer use of the system is quick,  
6 easy, and convenient. Consumers view product related information on the display screen  
7 included in the dispensing unit before and during the normal refueling process. This feature  
8 provides an optimum means of educating and informing a customer regarding the features and  
9 benefits of the additive products offered, as well as how to make and pay for a selection. If a  
10 customer does not wish to purchase an additive, the refueling transaction proceeds as normal.  
11 If, however, a customer does desire an additive, the system enables the customer to select  
12 among one or more types of additives, and, notably, to make a selection at any point during the  
13 refueling process. The customer merely presses a button located on the dispensing unit  
14 (typically on or near the display screen) to make a product selection. The invention also  
15 supports the ability of consumers to make an additive selection inside the fueling station or at a  
16 kiosk if it is desired to prepay for fuel and additive prior to the fuel transaction. Finally, in  
17 alternate embodiments product information and product selections may be made on the fuel  
18 dispenser, through electronic communications with the dispensing unit and the central network  
19 server.

20 Once a selection is made, computer-controlled electronic and hydraulic systems monitor  
21 fuel dispenser activity on a real-time basis, such that precise volume increments of the selected  
22 additive may be injected directly into the fuel refueling stream, commensurate with successive  
23 volume increments of fuel dispensed. Additive increments can be varied through configurable  
24 software logic adjustments, made either at compile time or through the provision of software  
25 options. In addition, dispensing can proceed in one of three modes of injection: In one  
26 embodiment, all dispensed fuel is treated with additive without regard to when an additive  
27 selection is made. Alternatively, only fuel dispensed subsequent to when an additive selection is  
28 made may <sup>be</sup> treated with additive. As another alternative, a preset volume of additive may be  
29 injected regardless of the volume of fuel dispensed. Following a transaction, each dispensing  
30 unit transfers additive sales data through the central network server to the station point-of-sale  
31 system so as to enable customers to pay for the additive purchased in the same form and  
32 manner as that of their fuel or other purchases: either at the fuel dispenser (via payment system  
33 integrated into the dispenser) or inside the store or at the kiosk. In the case of prepaid

1 transactions, such transfer of post-transaction additive sale data may be preceded by the  
2 transfer of additive authorization data prior to the sale.

3 The present invention advantageously enables fuel retailers and/or automotive  
4 consumers to select and add fuel additives into the fuel refueling stream at the fuel dispenser  
5 while an automobile is being refueled in the normal manner. Further, the present invention  
6 advantageously enables the cost of such additives to be integrated with the corresponding fuel  
7 transactions so as to enable customers to pay for the additive purchased in the same form and  
8 manner as that of their fuel or other purchases. Moreover, in accordance with a further aspect  
9 of the invention, existing stations may be upgraded (i.e., retrofitted) to include additive  
10 dispensing capabilities in accordance with the principles of the present invention without the  
11 need for extensive reengineering, remanufacture, and reinstallation of the existing fuel  
12 dispensers or point-of-sale systems.



## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and aspects of the subject invention will be best understood with reference to a detailed description of a specific embodiment of the invention, which follows, when read in conjunction with the accompanying drawings, in which:

Figure 1 is an exploded view of a conventional fuel dispenser and a fuel additive dispensing unit in accordance with one embodiment of the invention;

Figure 2 is a partially cut-away view of the fuel additive dispensing unit from Figure 1;

Figure 3. is a partially cut-away view of a fuel additive dispensing unit in accordance with an alternative embodiment of the invention;

Figure 4 is an illustration of a display and control module from the fuel dispensing unit of either the embodiment of Figure 1 or the embodiment of Figure 2;

Figure 5 is a state diagram representing operational states and events occurring in a fuel and fuel additive dispensing system in accordance with one embodiment of the invention;

Figure 6 is a state diagram representing operational states and events occurring in a fuel and fuel additive dispensing system in accordance with an alternative embodiment of the invention; and

Figure 7 is a block diagram of a fueling station showing the general manner in which each invention unit can be connected to a central network computer server, and a schematic of the primary communication linkages between a typical fuel dispenser, the invention, the central network server, and the station point-of-sale system.

## DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention makes use of and integrates two principal technologies: fuel dispensing systems and computer-based electronic control systems. In the disclosure that follows, in the interest of clarity, not all features of actual implementations are described. It will of course be appreciated that in the development of any such actual implementation, as in any such project, numerous engineering and programming decisions must be made to achieve the developers' specific goals and subgoals (e.g., compliance with system- and business-related constraints), which will vary from one implementation to another. Moreover, attention will necessarily be paid to proper engineering and programming practices for the environment in question. It will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the fields of computer and control system design and fuel dispensing technology having the benefit of this disclosure.

Referring to Figure 1, there is shown a fuel dispensing system 100 incorporating a fuel additive dispensing unit 102 in accordance with one embodiment of the invention. It is to be understood that Figure 1 is a partially exploded view, in that it shows the general manner in which the disclosed embodiment of a fuel additive dispensing unit 102 is attached to the side of a fuel dispenser 104 (sometimes referred to in common parlance as a "gas pump") by removing existing fuel dispenser side panel 106 and bolting or otherwise affixing dispensing unit 102 onto the side of fuel dispenser 104 at the prior location of the dispenser side panel 106. The installation process is reflected by arrows 108 in Figure 1 indicating how additive dispensing unit 102 is directed toward fuel dispenser 104 during an installation procedure. In the disclosed embodiment, the rigid (e.g. steel) external housing of dispensing unit 102 is sized and shaped so as to complement the configuration of the side of fuel dispenser 104, making the mating of dispensing unit 102 with fuel dispenser natural and aesthetically inconspicuous. Further, fuel dispenser side panel 106 may be reattached to the exterior side of dispensing unit 102, so as to preserve existing color schemes, brand name logos, and the like.

In the presently preferred embodiment of the invention, fuel dispensing unit 102 is adapted to be attached to the side of fuel dispenser 104, although it is to be understood that other configurations may be adopted, and that in alternative embodiments, dispensing unit 102 may be configured to be attachable at locations on dispenser 104 other than the side thereof. In one embodiment, dispensing unit 102 comprises a rigid (e.g., steel) housing.

Several additional connections are made between dispensing unit 102 and fuel

1 dispenser 104 to complete the physical installation. First, electronic cable(s) (not shown in  
2 Figure 1) from dispensing unit 102 are connected to cables emanating from each of the fuel  
3 flow meters and nozzle lift indicators inside fuel dispenser 104. Such connections enable  
4 electronic and computer circuitry inside dispensing unit 102 to monitor fuel flow rates on a real-  
5 time basis through monitoring of pulses or other outputs of the fuel flow meters, as displayed on  
6 fuel dispenser 104 on a display designated with reference numeral 141 in Figure 1. In addition,  
7 such connections also enable the electronic and computer circuitry of dispensing unit 102 to  
8 monitor the grade of fuel selected by the customer and the initiation and termination of fueling  
9 transactions on a real-time basis, as such events are conducted by a customer at a nozzle  
10 location 112 or other location.

11 Regarding display 140, it is contemplated that numerous known display technologies,  
12 including without limitation, liquid crystal display (LCD) screens, video display screens, and the  
13 like, will be suitable for the purposes of practicing the present invention. It is believed that those  
14 of ordinary skill in the art having the benefit of the present disclosure will be readily able to  
15 implement a suitable display 140 for the purposes of the invention as described herein.

16 In the disclosed embodiment, such electronic cable(s) use multiple pin connectors in  
17 which the electronic cable(s) from dispensing unit 102 tie in to cable(s) inside fuel dispenser  
18 104 emanating from each of the fuel flow meters and nozzle lift indicators. Such cables(s) are  
19 of various types, as necessary to fit each of various makes and models of fuel dispensers 104.  
20 All such cable(s) are integrated into fuel dispenser 104 in a manner so as not to interfere or  
21 alter normal fuel dispenser operation. In an alternate embodiment, such interconnections of  
22 dispensing unit 102 with the fuel flow meters and nozzle lift indicators inside fuel dispenser 104  
23 are accomplished via linkage to an interface box or other system that separately monitors and  
24 enables access to data and information regarding fuel dispenser activities and operating  
25 conditions.

26 Second, electronic cables from dispensing unit 102 connect to an electrical junction box  
27 (not shown in Figure 1) inside fuel dispenser 104 in a manner to enable dispensing unit 102 to  
28 receive electrical power from fuel dispenser 104.

29 Finally, fuel additive product flow lines emanating from dispensing unit 102 connect to  
30 each of the fuel flow lines inside the dispenser 104 at a convenient point such as that  
31 designated generally with reference numeral 114 in Figure 1, downstream of each fuel flow  
32 meter. In this way, fuel additives can be injected into the fuel refueling stream at fuel dispenser  
33 104 downstream of each fuel flow meter. At such point of interconnection 114, check valves

1 and/or other flow control means are used to prevent reverse flow of fuel or additive through fuel  
2 dispenser 104 or the fuel additive flow lines inside dispensing unit 102. With regard to the check  
3 valves, in the presently preferred embodiment, a model 2232T1-2MM check valve commercially  
4 available from Circle Seal Controls, Inc., Corona, California is believed to have the desired  
5 combination of internal components, pressure rating, and durability for the purposes of the  
6 present invention.

7 Those of ordinary skill in the art will appreciate that the means of such interconnection  
8 114 may be via custom-designed flanges, injection ports, or other suitable means, depending  
9 on requirements for each various make and model fuel dispenser 104. It is believed that the  
10 exact nature of the interconnection is not critical for the purposes of the present disclosure,  
11 beyond what has been stated above.

12 In various alternate embodiments, connections of fuel additive flow lines from dispensing  
13 unit 102 to fuel flow lines inside fuel dispenser 104 may be made at a point upstream of the fuel  
14 flow meters. In addition, dispensing unit 102 may alternatively be configured and attached to  
15 fuel dispenser 104 in a variety of manners and at various locations. It is believed that those of  
16 ordinary skill in the art having the benefit of the present disclosure will recognize and appreciate  
17 these and many other such design options and alternatives which may differ from  
18 implementation to implementation.

19 Turning now to Figure 2, there is shown a partially cut-away view of dispensing unit 102  
20 in accordance with the presently disclosed embodiment of the invention. In the embodiment of  
21 Figure 2, a fuel additive storage and pressuring unit 116 is located exterior to the body of  
22 dispensing unit 102. In this embodiment, a customer at fuel dispenser 104 would view display  
23 content on a display and control module 110 associated with dispensing unit 102, and make a  
24 selection at any point during the fueling transaction, for example by pressing a selection button  
25 such as button 117 in Figure 2 adjacent to or on display and control module 110. After a  
26 selection is made by the customer, electronic and computer circuitry integrated into the display  
27 and control module 110 of the invention senses such selection.

28 In the presently disclosed embodiment, display and control module 110 comprises  
29 electronic circuitry for controlling the display content of display 140, and further comprises  
30 circuitry and user interface means (e.g., buttons, touch-sensitive displays, and the like) for  
31 enabling a customer to select one or more options associated with the dispensation of fuel  
32 additives. It is believed that those of ordinary skill in the art having the benefit of the present  
33 disclosure would be readily able to implement the electronics associated with display and

1 control module 110 to achieve the functionality described herein; accordingly, the specific  
2 implementation details for display and control module 110 are described herein primarily in  
3 functional terms.

4 As will be hereinafter described in further detail, in accordance with one aspect of the  
5 invention display and control module 110 may be responsive to user interaction either before or  
6 during a fueling operation to initiate the dispensation of fuel additive into the stream of fuel  
7 dispensed from dispenser 104. This is believed to be a particularly advantageous aspect of the  
8 invention, since it enables <sup>the</sup> customer to initiate the dispensation of fuel additive even after a  
9 fueling process has begun.

10 A hydraulic module for controlling the flow of additive that is dispensed is designated  
11 generally with reference numeral 118 in Figure 2. After an additive selection is made by a  
12 customer, or indicated based on other criteria, fuel dispenser conditions are monitored through  
13 electronic cables designated with reference numeral 120, and electronic signals are sent  
14 through electronic cables 122 to direct the operation of input manifold(s) 123 and output  
15 manifold(s) 124 that are disposed within hydraulic module 118. Such operation causes the  
16 selected fuel additive product to flow from the additive storage means 116 by way of the  
17 pressure generated by a pump 126 into dispensing unit 102 through additive flow lines 128,  
18 safety breaks 130, and filtration means 132, into and through an additive flow meter 134  
19 integrated into hydraulic module 118, and then into the appropriate additive flow line 136. This  
20 in turn causes the selected fuel additive to be injected into the appropriate fuel flow line inside  
21 fuel dispenser 104. In one embodiment, pump 126 may be selectively turned on and off by  
22 electronic signals generated by display and control module 110.

23 Hydraulic module 118 in the presently disclosed embodiment provides fuel additive  
24 service to one or both sides of fuel dispenser 104 (i.e. both fueling positions), and in one  
25 embodiment is comprised of one or more sets of inlet flow control manifolds 123 and outlet flow  
26 control manifolds 124, upstream and downstream, respectively of a positive displacement flow  
27 meter 134. Each inlet manifold 123 incorporates one solenoid valve for each additive product.  
28 Each outlet manifold 124 incorporates one solenoid valve for each gasoline hose 113 plus one  
29 solenoid valve that allows flow to be redirected through a calibration testing line 125 for the  
30 purposes of volume accuracy testing. (As used herein, the term gasoline hose 113 will be used  
31 to refer to the familiar, typically flexible rubber hose having a nozzle at its distal end for manual  
32 insertion into the fuel tank of a customer's automobile. On the other hand, it is intended that the  
33 term "hose" as used herein shall be interpreted broadly to encompass any means by which

1 gasoline is dispensed from dispenser 104 into an automobile's gas tank, including all presently  
2 known such means and any means to be developed in the future.)

3 The terminus end of calibration testing line 125 includes a check valve (not shown) and  
4 a valve (also not shown) for control of flow testing and subsequent sealing by weights and  
5 measures officials. In the presently preferred embodiment, the check valve on calibration  
6 testing line 125 is a model SS-CHM4-10 valve commercially available from Swagelok Inc. The  
7 SS-CHM4-10 has been found to maintain a positive seal after closure, advantageously leaving  
8 consistent volumes of additive in the calibration line. This is believed to be desirable for  
9 maintaining consistent volume accuracy readings for weights and measures testing.

10 In operating mode, an upstream solenoid valve on an inlet manifold 123 is actuated  
11 corresponding to an additive selected by a customer, and a downstream solenoid valve on an  
12 outlet manifold 124 is actuated corresponding to the grade of fuel selected by the customer.

13 In calibration mode, an upstream solenoid valve on an inlet manifold 123 corresponding  
14 to an additive selected by an operator or testing official is actuated. A downstream solenoid  
15 valve on an outlet manifold 124 is actuated such that additive flow is redirected through  
16 calibration testing line 125.

17 Those of ordinary skill in the art will appreciate that in alternate embodiments, various  
18 combinations of manifolds, solenoid valves, flow meters, or calibration lines could be used to  
19 provide service to one or both sides of the fuel dispenser. Additionally, although the present  
20 disclosure speaks in terms of one or more discrete hydraulic "modules" 118, this is done solely  
21 for the purposes of ease of collective reference. It is to be understood that the various hydraulic  
22 elements (manifolds, solenoids, flow control meters and the like) comprising hydraulic modules  
23 118 may not be implemented in the form of discrete units physically segregated from other  
24 components of the overall system, but instead may be physically distributed and located in  
25 different positions with respect to dispensing unit 102 and dispenser 104, as implementation  
26 requirements dictate. It is intended that the term "hydraulic module" as used herein shall  
27 encompass any arrangement of the various hydraulic control elements necessary for  
28 performing the flow control functions described herein.

29 In the presently disclosed embodiment, manifolds 123 and 124 are conventional off-the-  
30 shelf components such as the No. 82626G208 solenoid valve commercially available from  
31 Automatic Switch Company (ASCO), Florham Park, NJ (<http://www.ascovalve.com>). ASCO  
32 uses the designations HP 274387, HP 274388, and HP 274401 to refer to configurations of  
33 8262G208 valves and manifolds presently preferred for the purposes of practicing the present

1 invention.

2 Flow meter 134 may be the Series 210 Positive Displacement Flow Meter commercially  
3 available from Max Machinery, Inc., Healdsburg, CA (<http://www.maxmachinery.com>).  
4 Specifically, the presently preferred flow meter for the purposes of practicing the present  
5 invention is the Max Machinery model 214-410-000 flow meter with V884 material, in  
6 association with a Max Machinery model 284-522-000 sensor and electronics assembly for  
7 monitoring flow meter activity and emitting electronic pulses commensurate with metered  
8 volumes.

9 Those of ordinary skill in the art having the benefit of the present disclosure will  
10 appreciate, however, that various forms and combinations of components such as described  
11 herein can be employed in additional embodiments, such as different configurations for additive  
12 storage and pressuring means, different numbers of additive flow lines and corresponding  
13 downstream or upstream components corresponding to multiple options of additive products  
14 offered to customers, different manifold and flow meter configurations, and the use of various  
15 numbers, types, and combinations of pumps and flow meters inside or outside dispensing unit  
16 102 to transport and accurately measure fluid volumes within the appropriate tolerances.

17 In operation, electronic and computer control circuitry and injection control software  
18 inside display and control module 110 enable the monitoring of customer activity and operating  
19 conditions at the fuel dispenser on a real-time basis through electronic cables 120, such that  
20 the information such as the gasoline grade selected, the initiation and termination of fuel flow,  
21 and actual fuel flow volume may monitored. For example, in one embodiment, fuel flow is  
22 monitored through the counting of electrical pulses recorded by the fuel flow meter, the number  
23 of pulses being proportional to fuel volume.

24 As noted above, it is believed that the specific implementation of the electronic circuitry  
25 needed to implement the functions and functionality described herein, particularly that of display  
26 and control module 110 are not critical for the purposes of the present invention, and that the  
27 design and implementation of such electronics would be a matter of routine engineering to a  
28 person of ordinary skill in the art. Accordingly, specific implementation details about the  
29 electronics in the disclosed embodiment shall not be further described herein.

30 As quantities of dispensed fuel are monitored, electronic signals from the electronic and  
31 computer control circuitry inside display and control module 110 through electronic cables 122  
32 cause the appropriate combination of solenoid valves to sequentially open and close to permit  
33 volume increments of the selected additive to be transported through positive displacement flow

1 meters. In the disclosed embodiment, such flow meter outputs a stream of electrical pulses, in  
2 which the number of pulses is proportional to fluid volume. Since the timing sequences for the  
3 opening and closing of solenoid valves can be affected by operating temperature, fluid  
4 pressure, flow rate, valve wear, solenoid type (e.g., AC or DC), and other factors, all of which  
5 can impact metered volume, dispensing unit 102 maintains a real-time log of valve timing,  
6 cumulative additive volume injected since a predetermined starting point and target cumulative  
7 volume injected. This data is processed by computer-controlled algorithms to enable automatic  
8 sensing, correction, and ensuing adjustment of subsequent valve timing and injected volumes  
9 to optimize metering accuracy. In one embodiment, adjustment of valve timing and injected  
10 volumes can be based upon assessment of past performance of the metering system and  
11 current hydraulic conditions as detected by the various sensors in the hydraulic module. This is  
12 referred to as an "adaptive metering" functionality.

13 In one embodiment, such computer monitoring and control preferably achieves metering  
14 accuracy to within approximately 0.75% tolerance levels, despite the relatively low volume of  
15 additive being dispensed. That is, in the presently preferred embodiment, hydraulic module 118  
16 is preferably capable of ensuring that the amount of additive actually injected into a fuel flow  
17 line is within 0.75% of the amount of additive selected and intended to be injected. Those of  
18 ordinary skill in the art will appreciate that such accuracy is particularly desirable given the  
19 relatively small amounts of additive that are typically dispensed during any given fueling  
20 operation. After each additive volume increment is metered, it is subsequently injected into the  
21 fuel stream through additive flow lines 136 into the fuel refueling stream at fuel dispenser 104.

22 Additive volume increments are preset quantities that are dispensed so as to  
23 correspond to successive predetermined volume increments of fuel dispensed. Through means  
24 of configurable injection control software and other electronic and computer control circuitry  
25 inside display and control module 110, dispensing unit 102 has the capability to inject additive in  
26 varying volume increments at any point during the fueling process, such as at the initiation of  
27 fuel dispensing or at any point during any monitored volume increment of fuel dispensed. For  
28 example, in one embodiment, dispensing unit 102 injects additive in predetermined volume  
29 increments (for example, 0.8 ounces at a time) at, for example, the beginning or the midpoint of  
30 each gallon volume increment of fuel dispensed. In alternative embodiments, a predetermined  
31 increment of additive may be injected at the beginning of each gallon of fuel dispensed, or at  
32 the end of each gallon of fuel dispensed, or at the beginning, end, or any other point during any  
33 desired increment of fuel. In still another contemplated embodiment, a single, predetermined



1 amount of additive, as opposed to multiple incremental amounts of additive, is injected; this can  
2 be likened to a customer purchasing a bottle of additive, for example, twelve ounces, and  
3 manually pouring it into a vehicle's gas tank.

4 Figure 3 is a partially cut-away view of an alternative embodiment of an additive  
5 dispensing unit 102' in which the fuel additive storage and pressuring means 116 is included  
6 within the body dispensing unit 102', rather than externally as in the embodiment of Figure 2. (It  
7 is to be understood that those elements in the embodiment of Figure 3 which are essentially  
8 identical to corresponding elements in the embodiment of Figure 2 have the same reference  
9 numerals in both of those Figures.) With the embodiment of Figure 3, customers at fuel  
10 dispenser 104 view display content on the display screen 140 associated with display and  
11 control unit 110, and make selections at any point during the fueling transaction by pressing a  
12 selection button 117 adjacent to or on the display and control module 110. After a selection is  
13 made by the customer, or indicated by other means (such as a preset additive condition on a  
14 prepaid additive sale) the electronic and computer circuitry integrated into the display and  
15 control module 110 senses such selection, and monitors fuel dispenser conditions through  
16 electronic cables 120 and directs the operation of manifolds 124 and valves in hydraulic module  
17 118 through electronic cables 122 such that the selected fuel additive product flows from the  
18 additive storage means 116 by way of the pressure generated by pump 126 through additive  
19 flow lines 127, and filtration means 130, into and through an additive flow meter 134 integrated  
20 into the hydraulic module 118, and then into the appropriate additive flow line 136 which in turn  
21 causes the selected fuel additive to be injected into the appropriate fuel flow line inside the fuel  
22 dispenser. In one embodiment, pump 126 can be selectively turned on and off by electronic  
23 signals generated by control and display module 110 in response to a customer selection of an  
24 additive or other event indicating an additive selection made or status of a transaction.  
25 Alternatively, pump 126 may be controlled from elsewhere, as will hereinafter be described with  
26 reference to Figure 6.

27 The further description of the physical and operating characteristics of the embodiment  
28 disclosed in Figure 2 is identical to that of the embodiment disclosed in Figure 3. In addition, as  
29 with the potential variability or location of the components in Figure 2, additional embodiments  
30 could make use of alternate equipment configurations, including various types and  
31 combinations of the pump 126 and filtration means 130 located either under, adjacent to, on, or  
32 inside the additive storage means and other various combinations, location, or types of other  
33 components as noted for the embodiment disclosed in Figure 2. In addition, the components,

1 mechanism, form and manner of the use and operation of the hydraulic module 118 and the  
2 variety of methods of additive injection and all other comments relative to the hydraulic module  
3 118 would be similar to such comments made relative to the hydraulic module 118 in  
4 connection with the description of the embodiment of Figure 2.

5 In the self-contained embodiment depicted in Figure 3, a suction pressure fill cap is  
6 employed to seal fuel additive and pressure means 116. In the presently preferred embodiment,  
7 this cap (not depicted in the Figures) is a model 60002 suction pressure fill cap commercially  
8 available from Central Illinois Manufacturing Company, Bement, Illinois.

9 Figure 4 depicts display and control module 110 in accordance with one embodiment of  
10 the invention. (Those of ordinary skill in the art will appreciate that display and control module  
11 110 is essentially the same in the embodiments of Figures 2 and 3, respectively; hence for the  
12 purposes of the following disclosure, references to dispensing unit 102 shall be interpreted as  
13 applicable to either embodiment, unless otherwise noted.) In the presently disclosed  
14 embodiment, display and control module 110 is essentially integral with the housing of  
15 dispensing unit 102, although those of ordinary skill in the art will appreciate that display and  
16 control module may be affixed to the housing of dispensing unit 102 or fuel dispenser 104 from  
17 the housing of dispensing unit 102 or fuel dispenser 104 and connected to the internal  
18 components of dispensing unit 102 via multiple cables or wires.

19 As noted above, display and control module 110 preferably houses key electronic and  
20 computer components and the display screen for presenting graphical and textual information  
21 to customers. Display and control module 110 includes multiple types of electronic and  
22 computer circuitry inside a display housing which may integrated into dispensing unit 102.

23 In one embodiment, display and control module 110 includes a display screen 140 that  
24 is segregated into different, specific viewing areas. In the example of Figure 4, display screen  
25 140 is segregated into three distinct viewing areas designated with reference numerals 142,  
26 144, and 146. Each viewing area 142, 144, and 146 is assigned a given function and is under  
27 the coordinating control of a specific, independent software code set that works in tandem with  
28 the electronic and computer circuitry in the display and control module 110 to enable each  
29 screen area to display different types/formats of text or graphical content independent from  
30 content that may be displayed on the other areas of the screen 140. In the presently preferred  
31 embodiment of the invention, display and control module 110 incorporates a computer platform  
32 that is essentially a conventional personal computer class of computer. For example, display  
33 and control module 110 may comprise a computer based on the well-known Intel™ Pentium™

1 class of central processing unit or the like, having conventional sub-components such as  
2 memory, graphics circuitry and the like associated therewith. Those of ordinary skill in the art  
3 will appreciate, of course, that certain functions of dispensing unit 102, including those of  
4 display and control module 110, may be performed by dedicated subsystems having their own  
5 processing capabilities. Such implementation-specific considerations are not believed to be  
6 particularly critical for the purposes of appreciating the present invention. It is believed that  
7 those of ordinary skill in the art having the benefit of the present disclosure would be readily  
8 able to implement a display and control module suitable for the purposes of practicing the  
9 present invention as a matter of routine engineering.

10 In the disclosed embodiment, an upper left portion of the screen 142 is used to display  
11 various types of video text, graphics, advertising, promotional and/or infomercial content related  
12 to the use and operation of the system, as well as fuel additive product choices, features, and  
13 benefits. Such screen area 142 is controlled by an independent software code set and time  
14 function in which one or more video and/or audio files stored on RAM within the electronic and  
15 computer circuitry of the display and control module 110 are accessed through configurable  
16 controls and directed to be displayed on screen area 142 during a specific state for either a  
17 specific time duration or until a specific event happens. For example, such specific event may  
18 be a customer action that triggers a change to a different state. Through the use of the  
19 independent software code set and time function, the display of such video and/or audio files on  
20 screen area 142 for any state can be controlled independent of each other and independent of  
21 content that may be displayed simultaneously on other screen areas.

22 A bottom portion of the screen 144 is used to display static or running totals of  
23 dispensed additive volume, updated on a real-time basis for volume and sale totals for  
24 dispensed fuel additive products. Such screen area 144 is controlled by an independent  
25 software code and is event-driven on a basis independent of the other screen areas. During an  
26 additive dispensing process, dispensed volume data is monitored and/or calculated for each  
27 increment of additive dispensed, and the screen area 144 is updated on a real-time basis as  
28 such information is received.

29 A right side of the screen 146 is used to display fuel additive product names and prices  
30 which correspond to context-sensitive selection buttons 117 located either on or adjacent to the  
31 screen 140. Such screen area 146 is controlled by an independent software code set which  
32 enables the display to be changed/updated based on one of three specific events. First, at the  
33 end of every sale, prices and product names can be read by the electronic and computer

1 circuitry within the display and control module 110 from configuration files in the central network  
2 server. The right portion of the screen is changed to reflect any such price or product name  
3 change that has occurred. Second, during an additive sale, the prices and/or product names of  
4 the "non-selected" additives are blanked-off, or erased from customer's view. This enables the  
5 customer to only see information corresponding to the selected product after a selection has  
6 been made. Third, the electronic and computer circuitry within the display and control module  
7 110 may receive a specific message from the central network server instructing it to reread  
8 price or product name information. If so, it rereads and updates such information, unless if  
9 such message is received while an additive transaction is in progress, it waits until the sale is  
10 completed to read and update such information. Through the use of such independent software  
11 code sets within the electronic circuitry of display and control module 110, each area of the  
12 screen can display different types/formats of text and graphical content either simultaneous with  
13 or independently from that displayed on the other areas of the screen 140, regardless of the  
14 content displayed in the other areas.

15 Display and control module 110<sup>6</sup> in the presently disclosed embodiment may further  
16 include additional components for facilitating consumer use of dispensing unit. An audio  
17 speaker 148 may be integrated into display and control module 110 to support the use of audio  
18 in conjunction the graphical content displayed on screen 140. A proximity detector 150 may  
19 also be integrated into the display and control module 150. Proximity detector 150 may  
20 advantageously be used to detect the presence of an approaching customer or automobile  
21 such that audiovisual content can be changed or initiated specifically for each customer, as the  
22 customer approaches a dispensing unit 102 or fuel dispenser 104 at the site. Proximity detector  
23 150 may be, for example, an infrared motion sensor or the like, such as is commonly employed  
24 for the purposes of detecting a person's presence in a particular area. In one embodiment,  
25 proximity detector 150 is responsive to the detection of a person in the vicinity of dispensing  
26 unit 102 and/or fuel dispenser 104 to generate an electrical detection signal applied to said  
27 control circuitry. Upon receipt of such a detection signal, display and control circuitry 110 may,  
28 for example, alter the content of display screen 140.

29 Those of ordinary skill in the art will appreciate that in alternate embodiments, the audio  
30 speaker 148 and the proximity detector 150 can be moved to locations on dispensing unit 102  
31 or fuel dispenser 104 other than those shown in the Figures, as desired in a given  
32 implementation.

33 Display and control module 110 may include an area 152 for a decal used to

1 communicate various types of information or promotional content to a customer. Finally; display  
2 and control module 110 is positioned on dispensing unit 102 at eye-level and within a  
3 customer's normal field of vision at the fuel dispenser 104, such that the module 110 is within a  
4 customer's line of sight and easy reach. For example, display and control module 30 in the  
5 disclosed embodiment is canted toward the customer at a 28° angle. In alternative  
6 embodiments, display and control module 110 can be mounted flush with fuel dispenser 102 or  
7 at higher or lower canting angles. Additionally, the display screen 140 and other components of  
8 the display and control module 110 can be integrated in a variety of a manners into the fuel  
9 dispenser 104 itself, in alternate embodiments.

10 As noted above, display and control module 110 incorporates one or more computers  
11 which can (1) by connection to a proximity detector 150 sense when a customer is within range  
12 of the device, (2) display various graphical and/or textual content to customers at the fuel  
13 dispenser, (3) interactively guide a customer through the selection of a product, (4) display the  
14 progress of a sale, (5) control the dispensing of a product, (6) communicate and receive a  
15 variety of authorization, sales, and transactional to and/or from a central network server.

16 Figure 5 is a state diagram of the state-specific display and control system logic  
17 employed by dispensing unit 102 in one embodiment of the invention. Through this system and  
18 associated electronic and computer-controlled systems integrated into dispensing unit 102,  
19 dispensing unit 102 monitors customer activity and operating conditions on a real-time basis at  
20 both dispensing unit 102 and the adjacent fuel dispenser 104. Such capability enables  
21 dispensing unit 102 to (1) change audiovisual content in response to customer activity or  
22 operating conditions on a real-time basis such that each customer at each dispensing unit 102  
23 or fuel dispenser 104 at a site is presented with individual, position-specific audiovisual content,  
24 (2) direct and control the fuel additive injection process on a real-time basis, and (3) facilitate  
25 linkages to the various transaction authorization, control, processing, and data storage  
26 functions that are necessary for dispensing unit operation and integration of fuel additive  
27 transactions with the corresponding fuel transactions such that payment of the additives is  
28 accomplished by customers in the same form and manner as that of the fuel or other  
29 purchases.

30 The state-specific display system uses a finite state machine, operating on embedded  
31 computers preferably within each display and control module 110 connected by a local-area  
32 network to one or more computer servers, to simultaneously control audiovisual presentation  
33 and additive injection and control operations. The server(s) control the commercial and "back

office" aspects of the sale, such as sales authorizations, billing, and interface to the station point-of-sale system, and storage of sales data. The server(s) also maintain sales and other historical data as desired or required by the Bureau of Weights & Measures or other state or federal regulatory agencies. The computer circuitry inside display and control module 110 generates the audiovisual display for screen 140 and controls the progress of a sale. Communications between the server(s) and each display and control module 110 within each dispensing unit 102 are facilitated through use of a real-time network protocol that enables constant, real-time interactions between the server(s) and each dispensing unit 102. Each display and control module 110 may be configured to record, maintain and/or transfer event and history logs on a real-time basis for storage on a server. This supports the server(s), maintenance of sales and other historical data as desired or required by Weights and Measures or other state or federal regulatory agencies as well the ability to review past operational events for analysis of code or equipment maintenance issues. The event logging methodology uses a variable, configurable debug level in which the level and volume of detail to be retained in the event log can be specified and/or adjusted as desired. Through use of the real-time network protocol to constantly inform the server(s) of dispensing unit or transaction conditions, the server(s) in tandem with each display and control module 110 use nonvolatile storage of network client data in tandem with battery back up on the network server(s) to enable the orderly transfer, storage and restoration of nonvolatile data. Other computers may be slaved in series or in parallel to accomplish various real-time functions. The use of the finite state machine facilitates interactivity between control operations, network communications, and the audiovisual interface.

The finite state machine includes capabilities to enable transactions in a variety of operating modes; payment by cash, credit or debit card either before or after fuel is pumped, with additive volume either preset based upon specification by the customer or automatically set by dispensing unit 102 in response to volume of fuel dispensed. Within each mode of operations, dispensing unit 102 monitors customer activity and equipment conditions at both dispensing unit and the fuel dispenser. Electronic signals are processed and acted upon by various of dispensing unit's electronic and computer circuitry. The state-specific events for one operating mode within the disclosed embodiment would be as follows.

With no customer at or in the vicinity of dispensing unit 102 or the fuel dispenser 104, dispensing unit is in the idle state represented by block 156. Dispensing unit 102 remains in this idle state 156 until a customer or automobile approaches. Various types of audiovisual content

1 can be presented during idle state 156, such as a "screen saver" which can be seen by passing  
2 motorists. As a customer or automobile approaches dispensing unit 102 and/or fuel dispenser  
3 104, proximity detector 150 senses their presence. Electronic signals are processed by the  
4 dispensing unit's electronic and computer circuitry and dispensing unit 102 enters into a  
5 standby state represented by block 158 in Figure 5. Various state-specific audiovisual content  
6 can be presented during standby state 158. In one embodiment, the system can be configured  
7 to bypass the idle state 156 altogether, such that a transition from the idle state 156 to standby  
8 state 158 is automatically made whenever the state machine attempts to enter idle state 156.

9 Standby state 158 is exited by one of three means. If an additive selection button 117 on  
10 dispensing unit 102 is pressed, a select state is initiated, as represented by block 160. More  
11 than one select state 160 may be provided, if different pre-pay modes are available, for  
12 example. Alternatively, if a fuel hook (designated with reference numeral 162 in Figure 1, for  
13 example) is activated by the customer at adjacent fuel dispenser 104, a presale state 164 is  
14 initiated. Finally, if no activity or change in equipment conditions at either dispensing unit 102 or  
15 adjacent fuel dispenser 104 is detected within a pre-selected time period, dispensing unit  
16 returns to the idle state 156.

17 From select state 160, various state-specific audiovisual content is presented. If the  
18 customer does not activate a fuel hook at the adjacent dispenser within a specified time period,  
19 dispensing unit returns to idle state 156. If the customer does activate a fuel hook 162 at  
20 adjacent fuel dispenser 104 within the specified time period, dispensing unit 102 enters a sale  
21 state 166. In the sale state 166, dispensing unit can present product-specific audiovisual  
22 content as it monitors fuel dispenser activity on a real-time basis, and directs and controls the  
23 precise injection of volume increments of fuel additives into the fuel refueling stream at the fuel  
24 dispenser through one of three presently contemplated dispensing modes. In a first dispensing  
25 mode, all fuel purchased is treated with additive regardless of when the additive selection was  
26 made. In a second dispensing mode, only fuel volumes that are dispensed subsequent to when  
27 an additive selection was made are treated with additives. In a third dispensing mode, a preset  
28 volume of additive is injected into the fuel, without regard to the volume of fuel dispensed.

29 Within each dispensing mode, dispensing unit 102 has the capability to vary the amount  
30 of each volume increment of additive or the point of injection corresponding to each volume  
31 increment of fuel. In addition, within each dispensing mode, dispensing unit 102 preferably has  
32 the capability to calculate whether or not the dispensed additive has traveled through the fuel  
33 hose and into the fuel tank. Those of ordinary skill in the art will appreciate that such capability

1 is achieved by monitoring, in dispensing unit 102, the flow of fuel out of fuel dispenser 104, as  
2 well as perhaps such parameters as the flow rate. Additionally, control circuitry in display and  
3 control module 110 is preferably informed as to the volume of fuel which can be contained in  
4 the system between the point of additive injection and the point at which the stream of fuel exits  
5 hose 113. With this knowledge, the control circuitry can ensure that each injected increment of  
6 additive is expelled from hose 113 before that increment of additive is accounted for (i.e.,  
7 charged to the customer). This feature advantageously prevents additive volume increments  
8 that have not reached the fuel tank from being billed to the customer. In addition, dispensing  
9 unit 102 preferably has the capability to display running total sale information for the product  
10 purchased on display screen 140 either by itself or simultaneously with the display of other  
11 video content on the screen.

12 Once the deactivation of a fuel hook at fuel dispenser 104 is detected (indicating that the  
13 fueling transaction has ended), dispensing unit 102 enters a collect state represented by block  
14 168 in Figure 5. Collect state 168 is a transition state in which fuel and/or additive transactional  
15 information is relayed to the central additive network server or the station retail point-of-sale  
16 system pending closing of the transaction. Once transactions are closed, dispensing unit 102  
17 enters a post-sale state represented by block 170 in Figure 5. From this state, sale amounts  
18 and other transactional data are transferred to data storage systems, which typically would be  
19 located at the central additive network server. Following the post-sale state 45, dispensing unit  
20 automatically reenters either the standby state 158 or the idle state 156.

21 From presale state 164 in which a fuel hook 162 at fuel dispenser 104 is activated but  
22 no additive button 117 is selected, dispensing unit presents various audiovisual content. If a fuel  
23 hook 162 at fuel dispenser 104 is deactivated prior to an additive selection button 117 being  
24 pressed by the customer (i.e. transaction ended), dispensing unit 102 enters collect state 168,  
25 and proceeds through subsequent states as indicated. If, on the other hand, an additive  
26 selection button 117 is pressed while dispensing unit 102 is in the presale state, dispensing unit  
27 102 can present to the user various state-specific and/or product specific audiovisual content,  
28 after entering the aforementioned sale state 166. Thereupon dispensing unit 102 proceeds  
29 through subsequent states as previously described.

30 Dispensing unit 102 supports variable display content in a configurable manner such  
31 that any single state on any dispensing unit 102 at a site can incorporate a wide variety of state-  
32 specific graphics types and formats, such as still slides without audio or motion video with  
33 audio. Such different types and formats can be displayed on different areas of the video display



1 screen simultaneously with different types and formats displayed on other display screen areas,  
2 if preferred.

3 The presentation of the state-specific audiovisual content and operating content  
4 sequences as described in Figure 5 is for one operating mode only (payment via cash after the  
5 fueling transaction is completed). Those of ordinary skill in the art will appreciate that multiple  
6 combinations and forms of similar state-specific process may be used for each of multiple  
7 modes of operation (e.g. post-pay cash inside, post-pay via credit card at the fuel dispenser,  
8 prepay cash or credit inside, and so on), including multiple additional states which may be  
9 added before, during, or after the states described with reference to Figure 5.

10 In Figure 6, there is shown a state diagram illustrating the operation of the finite state  
11 machine of dispensing unit 102 in accordance with an alternative, and presently preferred,  
12 embodiment of the invention. The operation of the state machine illustrated in Figure 6 can  
13 perhaps best be appreciated with reference to the following Table 1, which sets forth the  
14 operational status of dispensing unit 102 in each of the states. Table 1 further sets forth simple  
15 examples of the types of messages or content that might be displayed on display and control  
16 unit 110 in each of the states, it being understood that in actual implementation, such messages  
17 and content would likely be more "consumer friendly."

TABLE 1

REF. NO.	STATE NAME	DESCRIPTION	EXAMPLE MESSAGE
172	IDLE	This is the equivalent of a "screen saver" on a desktop computer, corresponding to a situation in which dispensing unit 102 has been idle for some period of time and proximity detector 150 does not detect the presence of a customer. Display and control unit 110 may display advertising content, for example.	(Screensaver)
174	STANDBY	The transition from IDLE to STANDBY occurs upon the detection of a potential customer by proximity detector 150. In this state, display and control unit 110 may display content intended to encourage the potential customer to include an additive with his or her purchase.	"Welcome."
176	PRESALE	In this state, display and control unit 110 is aware that the customer is purchasing fuel, but no additive has been selected. Display and control unit 110 may display	"Thank you for your fuel selection; would you like additive as well?"

TABLE 1

REF. NO.	STATE NAME	DESCRIPTION	EXAMPLE MESSAGE
		an inquiry as to whether the customer would like to purchase additive as well.	
178	POSTPAY	The POSTPAY state is entered when the customer has arranged to pay for fuel (and possibly additive) after fuel has been dispensed. An example of this is the familiar "Pay Inside Credit" option found on many conventional fuel dispensers. In the POSTPAY state, display and control unit 110 initiates a transaction by requesting authorization for a specific additive from the computer control circuitry (to be hereinafter described in further detail with reference to Figure 7). The computer control circuitry replies with an authorized dollar amount.	"Transaction authorized."
180	PUMP PAUSE	This state represents a pause in the operation of the state machine while fuel is being dispensed.	"Start fueling; your additive will be dispensed."
182	FUEL SELECT	This state is entered when the customer selects an additive before selecting a fuel type.	"Please select fuel before selecting an additive."
184	ADDITIVE SELECT	If display and control unit 110 is notified of a pre-paid transaction, it notifies the user to either select an additive or select no additive. For prepaid transactions, the computer control system initiates the additive transaction, and display and control unit 110 receives authorization for dispensing additive as soon as the customer begins the fueling transaction. Alternatively, display and control unit 110 can receive an authorization request which requires that an additive be selected before the sale can proceed. A customer can optionally specify "no additive."	"Is an additive desired?"
186	NO SALE	This state is entered if display and control unit 110 is notified of a pre-paid transaction that is expressly not to include additive.	(no message)
188	SALE	This state is entered when dispensing unit 102 begins dispensing additive.	"Additive is being dispensed."
190	COLLECT	This state is entered when the sale of additive is being posted to the point-of-sale system, after the dispensing of fuel and additive has completed.	"Your sale is being posted. Please make payment as arranged."
192	POST-SALE	This state is entered after the sale of	"Thank you for buying

TABLE 1

REF. NO.	STATE NAME	DESCRIPTION	EXAMPLE MESSAGE
		additive has been posted.	additive."
194	INFORMATION	The transition from STANDBY state 174 or PRESALE state 176 occurs if a customer requests information about additives.	"Here are the additives available, and this is what they do...."
196	ERROR	Several possible error conditions may arise. For example, dispensing unit 102 may be purposefully disabled. A customer's attempt to select an additive may be denied unless cash is paid in advance. The computer network controlling one or more dispensing units 102 (to be hereinafter described in greater detail with reference to Figure 7) may be inoperative, preventing the dispensing of additive. Meters and gauges within dispensing unit 102 may detect an error during the attempted dispensing of additive.	A message appropriate to the type of error occurring may be displayed. Alternatively, the message "System disabled" may be displayed.

Turning now to Figure 7, there is shown a simplified block diagram of an overall fueling station retail transaction system 200 incorporating one embodiment of the present invention. Based on the description which follows, those of ordinary skill in the art will recognize that system 200 in Figure 7 includes the principal components of current state-of-the-art retail fueling station systems, plus similar components to effect the incorporation of fuel additive dispensing capabilities in accordance with the principles of the present invention. System 200 includes one or more fuel dispensers 104 (for clarity, only one of which being shown in Figure 7) having fuel additive dispensing units 102 associated therewith (again, only one of which being shown in Figure 7). System 200 further comprises a central POS network server 210 to which each fuel dispenser 104 is connected via communication link 206. Further, POS network server 210 is coupled by communications link 209 to central additive network server 202 to which each fuel additive dispensing unit 102 is connected by a communications link 207. Communications link 209 enables the integration of fuel additive transactions with corresponding fuel transactions.

It is to be understood that communication links 206, 207, and 209 may take various forms. In some cases, communication links may be established by means of hard wiring, typical of conventional computer network configurations. Alternatively, communications links may be

1 established for the purposes of the present invention via wireless (e.g., radio frequency or  
2 infrared) communication channels. In any event, for the purposes of the present disclosure, it  
3 suffices to describe communications links 206 as channels by which information regarding the  
4 operational status and transaction information of each fuel dispenser 104 can be transmitted to  
5 central POS server 210, communications link 207 as the channel by which the operational  
6 status and transaction information of each dispensing unit 102 can be communicated to central  
7 additive network server 202, and communications link 209 as the channel by which operational  
8 status or transaction information of a dispensing unit 102 can be communicated to central POS  
9 server 210 by way of central additive network server 202.

10 Central POS server 210 is commonly part of an existing station point-of-sale ("POS")  
11 system 208. Module 212 is the "cash register" at which consumers can consummate  
12 transactions for the sale of fuel (and other items). Typically, POS system 208 is located within a  
13 store or kiosk at the fueling station. In one embodiment, POS system 208 comprises a  
14 computer 210 and user terminal 212. POS system 208 is also preferably coupled to each fuel  
15 dispenser 104 via a communications link 206 and to central additive network server 202 via a  
16 communications link 209 and by association to each fuel additive dispensing unit 102 via  
17 communications link 209

18 In general, each dispensing unit 102 is designed such that it can either be connected to  
19 POS system 208 through fuel dispenser 104, and/or it may be connected via network  
20 communication link 207 to central additive network server 202 supporting the various  
21 transaction authorization, control, processing, and data storage functions that are necessary for  
22 dispensing unit operation and the integration of fuel additive transactions with the  
23 corresponding fuel transactions such that payment of the additives can be made in the same  
24 form and manner as that of the fuel or other purchases. Due to the preferability of avoiding the  
25 extensive system hardware/software redevelopment that would be required to upgrade (e.g.,  
26 retrofit) existing station point-of-sale systems to incorporate all required dispensing unit  
27 functionality, the disclosed embodiment contemplates the separate network control server  
28 alternative as depicted in Figure 6.

29 In one embodiment, each dispensing unit 102 at a site location attaches to a fuel  
30 dispenser 104 and is connected to separate central additive network server 202 such that each  
31 dispensing unit 102 sends and receives sales authorizations and transactional data primarily to  
32 and from the central additive network server 202, and each fuel dispenser 104 sends and  
33 receives sales authorizations and transactional data primarily to and from the existing point-of-

1 sale system 208. Both central additive network server 202 and the retail station POS system  
2 208 are typically located inside a store or kiosk (not shown in Figure 7). In a typical  
3 configuration, both the central network additive server 202 and retail station POS system 208  
4 use network message communications protocols or other means to communicate via links 209  
5 respectively with each dispensing unit 102 associated with a fuel dispenser 104.

6 In another embodiment, each dispensing unit 102 may be provided with a credit card  
7 reader for enabling a customer to pay for fuel additive separately from the fuel itself. Those of  
8 ordinary skill in the art will appreciate that such a credit card reader may be exposed on the  
9 face of display and control module 110 to enable a user to select and pay for a desired fuel  
10 additive. Control information regarding the selection of and payment for additive may be  
11 communicated to central additive network server 202 and/or POS system 208 in the manner  
12 described herein.

13 In a typical operating mode configuration (payment via cash after the fueling transaction  
14 is completed), a customer lifts a nozzle 162 at the fuel dispenser 104, and fuel dispenser 104  
15 requests authorization from POS system 208. Once authorization is received, fuel dispenser  
16 104 begins dispensing fuel. At such point that the customer selects an additive at dispensing  
17 unit 102, dispensing unit 102 monitors such selection, and requests authorization from central  
18 additive network server 202. Once authorization is received, dispensing unit 102 dispenses  
19 additive into the fuel refueling stream at the fuel dispenser 104 during the fuel refueling process  
20 under one of three dispensing modes as previously described. After the fueling transaction is  
21 completed, fuel dispenser 104 transmits fuel sale information to POS system 208, and  
22 dispensing unit 102 transmits fuel additive sale information to central additive network server  
23 202. By means of computer network integration, POS system 208 then receives the fuel  
24 additive sale information from central additive network server 202 such that the fuel additive  
25 sale information can be matched with and posted to the corresponding fuel sale information. In  
26 this manner, the customer can pay for the cost of the fuel additive purchase at the same time  
27 and place, and in the same form and manner, as that of the fuel or other purchases.

28 In another operating mode configuration (payment via cash prior to a fueling transaction  
29 being initiated in which a preset amount of additive is requested by the customer), a customer  
30 pays the cashier inside the store or kiosk and returns to fuel dispenser 104. Through computer  
31 integration means, POS system 208 sends a preset additive volume message to central  
32 additive network server 202 indicating the selected additive amount and the designated fuel  
33 dispenser 104. Central additive network server 202 authorizes the corresponding dispensing

1 unit 102 and such dispensing unit 102 dispenses additive into the fuel refueling stream at the  
2 fuel dispenser 104 during the fuel refueling process under one of three dispensing modes as  
3 previously described. After the fueling transaction is completed, fuel dispenser 104 transmits  
4 fuel sale information to POS system 208, and dispensing unit 102 transmits fuel additive sale  
5 information to central additive network server 202. By means of computer network integration,  
6 POS system 208 then receives the fuel additive sale information from the central additive  
7 network server 202 for ensuing processing.

8 In yet another operating mode configuration (payment via cash prior to a fueling  
9 transaction being initiated in which the customer is not required to specify his/her desire for an  
10 additive at the time of prepayment), a customer pays the cashier inside the store or kiosk and  
11 returns to the fuel dispenser 104. Through computer integration means, POS system 208 sends  
12 a prepay fuel volume message to the central additive network server 202 indicating the total  
13 prepaid amount and the designated fuel dispenser 104. POS system 208 also delays  
14 authorization of the appropriate fuel dispenser 104 pending receipt of a prepay allocation  
15 message from central additive network server 202. Central additive network server 202 informs  
16 the appropriate dispensing unit 102 of such prepay condition, and such dispensing unit  
17 monitors ensuing customer selections of fuel and fuel additive, and informs the central network  
18 server of such selections. If no additive is selected, central additive network server 202 sends a  
19 prepay allocation message to POS system 208 indicating that 100% of the prepaid amount  
20 should be allocated to fuel. POS system 208 then authorizes the appropriate fuel dispenser 104  
21 for such amount. If, however, an additive is selected, central additive network server 202 uses a  
22 prepay allocation algorithm to calculate the respective amounts of fuel and additive that should  
23 be dispensed, based on the total prepaid amount, the fuel grade and additive type selected and  
24 their respective retail prices and fuel additive treat rate (i.e., the volume of additive dispensed  
25 per volume of fuel dispensed). After such calculation, central additive network server 202 sends  
26 a prepay allocation message to POS system 208 indicating the amount of the prepaid amount  
27 to be allocated to fuel. POS system 208 then authorizes the appropriate fuel dispenser 104 for  
28 such amount, and central network additive server 202 authorizes the appropriate dispensing  
29 unit 102 for the prepaid amount to be allocated to the selected additive. Dispensing unit 104  
30 then dispenses additive into the fuel refueling stream at the fuel dispenser 104 during the fuel  
31 refueling process under one of three dispensing modes as previously described. After the  
32 fueling transaction is completed, fuel dispenser 104 transmits fuel sale information to POS  
33 system 208, and dispensing unit 102 transmits fuel additive sale information to central additive

1 network server 202. By means of computer network integration, POS system 208 then receives  
2 the fuel additive sale information from central additive network server 202 for ensuing  
3 processing.

4 In yet another operating configuration (a prepaid fuel-only transaction in which a  
5 customer specifies to the cashier that no additive is desired), a customer may prepay to the  
6 cashier. The station POS system 208 sends a message via communications link 209 informing  
7 central additive network server 202 of a fuel-only prepay transaction. In this case, central  
8 additive network server 202 "disables" the respective dispensing unit 102 for the duration of the  
9 fuel transaction.

10 The description of such communications and operations for the various operating mode  
11 configurations are but one of many similar processes that systems in accordance with the  
12 present invention may employ, depending on the type of point-of-sale system and the overall  
13 mode of operation (e.g. post-pay cash inside, post-pay via credit card at the fuel dispenser,  
14 prepay cash or credit inside, etc.) to direct, control, and process transactions. Such  
15 communications protocols for such communications can be via network messages or serial port  
16 communications in a variety of forms and manners, as would be familiar and appreciated by  
17 those of ordinary skill in the art. In total, systems in accordance with the present invention  
18 support a wide variety of configurations, including the inclusion or integration of some or all  
19 dispensing unit control and functional capabilities within the fuel dispenser and station POS  
20 system 208 if desired. As with this and other aspects of the invention, it will be apparent to  
21 those of ordinary skill in the art that many embodiments of the subject invention may be  
22 designed that are not described in specific detail herein.

23 From the foregoing detailed description, it should be apparent to those of ordinary skill in  
24 the art that a method and apparatus for dispensing fuel additives simultaneously with the  
25 dispensation of fuel in a retail setting has been disclosed. Systems in accordance with the  
26 disclosed embodiment of the invention are advantageously adapted to be incorporated into  
27 existing retail fueling station systems, and are adapted to be operable before and during the  
28 normal fuel dispensing process.

29 As described above, the invention in part involves the use of computer-based electronic  
30 systems, of which many personal and industrial grades and types are available. The  
31 programming necessary to implement the functionality described herein is believed to be within  
32 the capability of any competent programmer, and may be accomplished through the use of a  
33 program storage device readable by the processor that encodes a program of instructions

1 executable by the processor for performing the operations described above. The program  
2 storage device may take the form of, e.g., a floppy disk; a CD-ROM; a memory device (e.g.,  
3 RAM, ROM, EPROM, EEPROM, etc.); and other forms of the kind well-known in the art or  
4 subsequently developed. The program of instructions may be "object code," i.e., in binary form  
5 that is executable more-or-less directly by the computer; in "source code" that requires  
6 compilation or interpretation before execution; or in some intermediate form such as partially  
7 compiled code. The program storage device may be one that is directly readable by the  
8 processor, or it may be one that is unusable by the processor per se but that provides  
9 intermediate storage of the program of instructions. The program of instructions may be read  
10 directly from the program storage device by the processor; alternatively, the program of  
11 instructions may be temporarily or permanently stored in the program storage device and  
12 transmitted from it to the processor over one or more links, e.g., over a telephone connection  
13 (such as a modem connection or an ISDN line); over a cable-modem hookup; over the Internet;  
14 via radio- or satellite transmission; etc., possibly with other program storage devices providing  
15 intermediate storage along the way. The precise forms of the program storage device and of  
16 the encoding of instructions are immaterial here.

17 Although specific embodiments of the invention have been described herein in some  
18 degree of detail, this has been done merely to illustrate various features and aspects of the  
19 present invention, and is not to be construed as limiting the scope of the invention as defined by  
20 the claims which follow. Those of ordinary skill in the art will appreciate that various  
21 substitutions, alterations, and/or modifications, including but not limited to those design  
22 variations and options that have been specifically noted herein, may be made to any of the  
23 embodiments of the invention disclosed herein without departing from the spirit and scope of  
24 the claims which follow.